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THE magazine TEXTILE RESEARCH is one of the most important services rendered to members by U. S. Institute. One annual subscription is covered by the dues of each member.

Because an unexpected number of subscriptions have been received from libraries, and from non-members in this and foreign countries, it has been found necessary to advance the non-member subscription price to $5.00 per volume and year (November to October inclusive), which is more nearly equal to the present cost of production.

Postal regulations, covering second-class mailing privileges, make necessary an advance in subscription price to members for more than one copy annually, to $2.50. Members have the privilege of subscribing to extra copies, and several have taken advantage of it to provide their key men with personal copies. Because there is a substantial loss to U. S. Institute on all member's subscriptions, it is hoped that members will utilize this privilege with discretion.

TEXTILE RESEARCH

EDITORIAL

The Research Literature Survey

THE founders of U. S. Institute for Textile Research realized and emphasized the need of a central library of textile and allied research, and of other textile literature of value to the textile research worker. Realizing that the raising of funds for such an enterprise must await more general interest in, and utilization of, scientific and economic research by the industry, your first board of directors, as advised by our first president, the late Dr. S. W. tratton, commenced publication of abstracts of current research throughout the world and the assembling of as many complete reports of such research as possible. This service, eventually, will become invaluable for reference purposes, but can never approximate that which a library could perform.

"*The Survey of Textile Research in the United States, 1931,*" that was compiled by U. S. Institute for The Textile Foundation, again emphasized the need of a central textile research library, and it is again stressed, and in a practical manner, by the first installment, published in this issue, of the literature survey of Wayne A. Sisson, a senior fellow of The Textile Foundation, who is conducting research on the "X-ray Analysis of Fibres." This work of Mr. Sisson, which is preliminary to his actual research, occupied his time for some three months and covered a total of 193 reports, books and articles, yet X-ray work on cellulose was started only 15 years ago. It was made necessary, as he writes, "to prevent needless repetition of past work and to acquaint ourselves with the published data." The

bibliography of the subject that he has prepared will be invaluable to future researchers.

The literature survey is a necessary preliminary to all research work, and, for each industry engaged in research, a central library of published source material would be found an invaluable saver of effort and time for research workers, to say nothing of its general reference value. Such a library is a major objective of U. S. Institute, but, until the requisite funds are available, the abstract and bibliography sections of *Textile Research,* its published research reports, and the meagre supply of source material accumulated by your secretary, may be the limit of our library service.

The Economic Research Program

THE four economic subjects that have been selected for study by the Committee on Economic Research, and that are the result of a preliminary survey of trade opinion, undoubtedly will be recognized as the major economic problems of the textile industry and of most other industries. They are listed and explained in a statement by the Committee appearing on another page, which report is introductory to a request that all who have done, or are doing, research on these subjects will advise the Committee of it.

This is, in effect, a literature survey, but, instead of being confined to published matter, it recognizes that the most valuable thought on these subjects may not have been made public; therefore, anyone who has carried the study of any of the problems to the point where conclusions indicate the basic principles involved, is requested to make them, and an outline of the analysis, available.

The preliminary report of the committee showed that these problems are common to all branches of the textile industry. Were the literature research to cover other industries, it probably would be found that the basic economic principles of the problems are also common to all industries. If this be true, might it not then be logical, and economical of time and effort, to endeavor to make this part of the study a cooperative research of representatives of all industries?

New Fabric Thickness-Measurer

By GEORGE B. HAVEN, S.B.*

MEASUREMENTS of the thickness of fabrics and the diameter of yarns and cords are accompanied by many variables, the exact character and effect of which it is practically impossible to determine. The ordinary use of the textile gauge or micrometer generally ignores these variables and consequently gives a result which frequently is difficult of duplication upon the same piece of goods.

With the hope of eliminating as many variables as possible, and coming to an agreement about all necessary ones, the author has made an extended study of gauge measurements, using a variety of methods and appliances for the purpose.[1] From this study, it is evident that the following variables are present in gauge measurements:

(*a*) Size of presser foot.
(*b*) Form of presser foot.
(*c*) Weight on presser foot.
(*d*) Velocity of presser foot in applying load.
(*e*) Time elapsing during measurement.
(*f*) Stability of machine.
(*g*) Condition of specimen during measurement.

(*a*) Size of Presser Foot

The wide variety of details mentioned above results in an equally extended amount of indentation of the presser foot into the fabric, as well as of the intensity of the load applied. Other things being equal, a fairly large presser foot will mechanically average minor variations in thickness, and it is therefore suggested that for all fabric determinations a presser foot one inch

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[1] *Editor's Note.* See *Mechanical Fabrics.* Haven, George B.; John Wiley & Sons, Inc., New York, 1932. P. 206 seq.

in diameter shall be made standard. This may entail some changes in printed specifications, but if the fabric is in a fairly uniform and flat state of finish, it is surely better to take the average thickness over a fairly good-sized area than it is to confine the measurement to such an area as that provided by the ratchet micrometer $^3/_{16}$ in. in diameter, or any of the small presser feet used in commercial instruments.

(*b*) Form of Presser Foot

Unhappily, there has come into vogue a wide use of circular presser feet in the measurement of the thickness of yarns and cords. Such specifications generally state that four cords or yarns shall be stretched across the table "close together" and that the diameter shall be measured of the four at once. Nothing is said in such specifications regarding the position of the four strands of yarn under the circular presser foot. Evidently, if these are stretched with care across the center of the foot they will suffer a certain amount of compression by the weight of the foot. If they are carelessly placed near the edge of the circular foot there will be less than half as much yarn under the foot for the purposes of measurement, and the resulting compression of the material will be much greater. In the opinion of the author this is a poor way to specify the measurement of cord diameters. If it is desired to load a definite length of cord for purposes of diameter measurement, it is logical that a square or rectangular foot only should be used for such a purpose. If the yarn is stretched precisely across such a foot, there will be a perfectly definite length under measurement, and the same cannot be varied without gross carelessness. It is, therefore, proposed that for cords, yarns and similar materials a presser foot one inch square shall be made standard.

(*c*) Weight on Presser Foot

Evidently, the use of springs with varying degrees of compression in cloth micrometers is not to be commended. If a very thick carpet or plush is used, the coiled spring may practically become "closed" in such use. This will very greatly increase the load upon the foot and will give a far different thickness measurement from either the microscope, or any other physical

apparatus. It is surely logical that as much of the friction as possible should be eliminated from the moving parts of the gauge measurer and that springs should be entirely eliminated, a dead weight of known and predetermined amount being substituted therefor. It is not difficult to remove the springs from commercial gauge measurers and attach a light aluminum scale pan to the top of the sliding ram. In this may be deposited the weights with which, plus that of the ram itself, it may be desired to impress the fabric. In this manner a definite amount of loading may be secured, invariably the same whether the ram is high or low in its position. This method has been employed by numerous research laboratories and has always secured a much greater degree of uniformity in gauge measurements than heretofore. It is proposed, therefore, that, for ordinary fabrics, the total load upon the presser foot, including that of the ram itself, should be four ounces. For cords and yarns, where the diameter is of no significance except as a means of comparison, it is evident that there should be as little flattening of the specimen as possible; therefore, a total weight of two ounces on the foot is proposed for such material. It is, of course, conceivable that, with large cords amounting to small ropes, or with very stiff duck, the above weights would not be sufficient to hold the specimen accurately in place. For such purposes the scale pan method may be adapted to any desired degree of compression which may appear to the observer.

(*d*) Velocity of Presser Foot in Applying Load

This is the item in which there has been the greatest degree of discrepancy and carelessness. When it was desirable to make the fabric appear thin, the foot was dropped a matter of ½ in. or more; under the reverse inclination the velocity of the foot was lowered to a negligible amount. It is evident that, unless some mechanical means is provided which is wholly under the control of the operator, no definite presser foot velocity can ever be secured. A few years ago the U. S. Bureau of Standards instituted a series of thickness measurements upon numerous very difficult specimens. These were sent to many laboratories, packed for transportation in a very perfect manner. The lab-

oratories were requested to make their usual thickness measurements upon the goods. The results, all of them obtained by the most natural and honest methods, exhibited a variation of 100% or more, and led the author to the conviction that the present methods for obtaining this quantity were little better than useless.

With this fact in view, the apparatus, illustrated and described in this paper, was designed and built. The personal equation is entirely eliminated from the question of foot velocity. The ram is lowered upon the goods at a definite and predetermined speed, the same being independent of the operator's desire or inclination. It is proposed, therefore, that for thickness measurements, the presser foot shall be lowered with a uniform velocity of 12 ins. per minute. This happens to be the usual speed of testing machine jaws, though this is of no significance and is a moderate and easily obtainable velocity. This can be done without complication, and does not retard the time consumed in obtaining thickness measurements to any reasonable degree.

(*e*) Time Elapsing During Measurement

It is evident that the rigidity of the standing fiber in napped and pile fabrics is dependent upon the time during which the compressive load is applied. Even though the compressor foot is applied with definite form, size and velocity, the indentation into such deep fabrics will be dependent upon the time of contact. With a deep fabric the compressor foot will continue to settle into the goods as fast as the standing fibers are bent, depressed and compacted. The dial, therefore, should be read when a definite interval of time has passed after contact has been made. It is proposed that a definite interval of five seconds shall be allowed to elapse after the contact has been made. This will enable the operator to estimate the fourth significant figure on the dial, even though there continues to be a slow movement of the finger during this time.

(*f*) Stability of Machine

It is evident that vibration would cause deeper and deeper penetration of the foot into the mass of the fabric under meas-

urement. This must be eliminated to the greatest possible degree. Such measurements of thickness are in every sense akin to those of the fine balance. The gauge measurer should, therefore, be supported in a stable condition upon a masonry foundation precisely similar to those employed in fine weighings.

(*g*) Condition of Specimen during Measurement

It is well known that moisture "fulls" and thickens fabrics and yarns. All goods, therefore, before measurement should be brought to a thorough and stable degree of moisture condition. For this it is proposed that the usual Government standards of 70° F. temperature and 65 per cent. relative humidity shall be employed. This is easily secured in most modern laboratories, and adds a certain degree of uniformity to the results obtained in thickness measurements.

Under this head also should be added the tension employed in the material, especially if yarn or cord is under measurement. It is evident that tension reduces the diameter of such materials as well as the thickness of fabrics. While the latter quantity is of relatively small importance, a certain uniform tension should always be employed when measuring cables, plies, or single yarns. There has been much speculation among experimenters regarding this value, and numerous arbitrary amounts have been suggested, none of which are wholly satisfactory. It is the opinion of the author that, in measurements of fabric alone, this variable is not of sufficient importance to require standardization, especially for commercial measurements. When the thickness of the material is a matter of keen dispute, it would probably be wise to include a standard tension in the goods when measured. A strip specimen would be necessary for such a purpose, and should naturally be somewhat larger than the diameter of the presser foot. It is, therefore, suggested that for fabrics under dispute a strip specimen 1½ ins. wide shall be used and shall be stretched under the presser foot with a tension equal to one-half the standard weight of the goods in ounces per square yard. For sheetings and print goods this would amount to 3 or 4 ozs.; for ducks and canvasses the figure might rise to 16 or 24 ozs. However, these heavy canvasses need

a certain amount of tension in order to place them in a suitable condition for thickness measurement. In the matter of cords and yarns it is suggested that each separate specimen, no matter how many are measured at once, shall be loaded with a weight in ounces equal to one divided by the number of the cord or yarn in the English or cotton system of notation. For tire cords

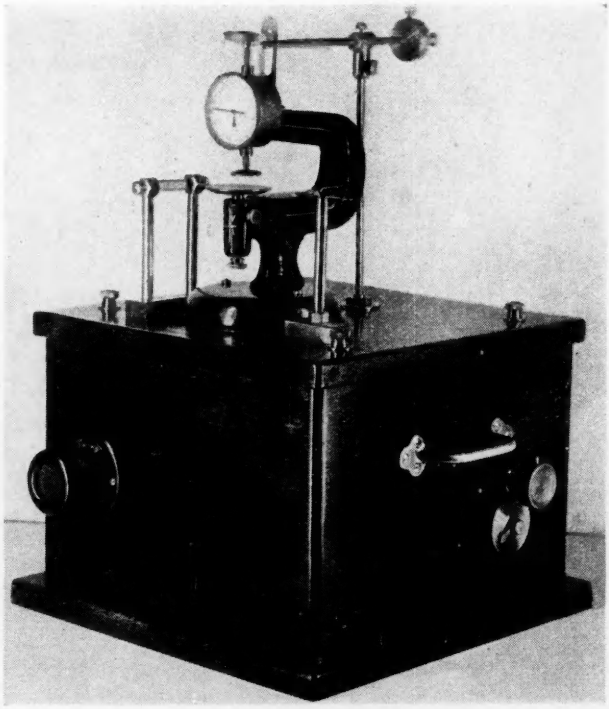

FIG. 1. Front of Thickness-Measurer, viewed from right-hand side.

this would amount to about 0.8 ounce per cord; for sheeting yarn the tension would be about $\frac{1}{30}$th of an ounce. It is, of course, necessary in light yarns to employ very small amounts of tension, if they are to be preserved in a form suitable for measurement of the diameter.

Description of Apparatus

With the preceding ends in view, the apparatus illustrated in Fig. 1 was devised by the author and built under his direc-

tion. It consists of the frame, dial and moving parts of a long-reach Randall & Stickney textile micrometer. The springs have been totally removed from the instrument, and the ram is free to move up and down with simply its own weight and a very light friction to govern it. To the top of the ram is attached a small circular scale pan in which any desired scale weight

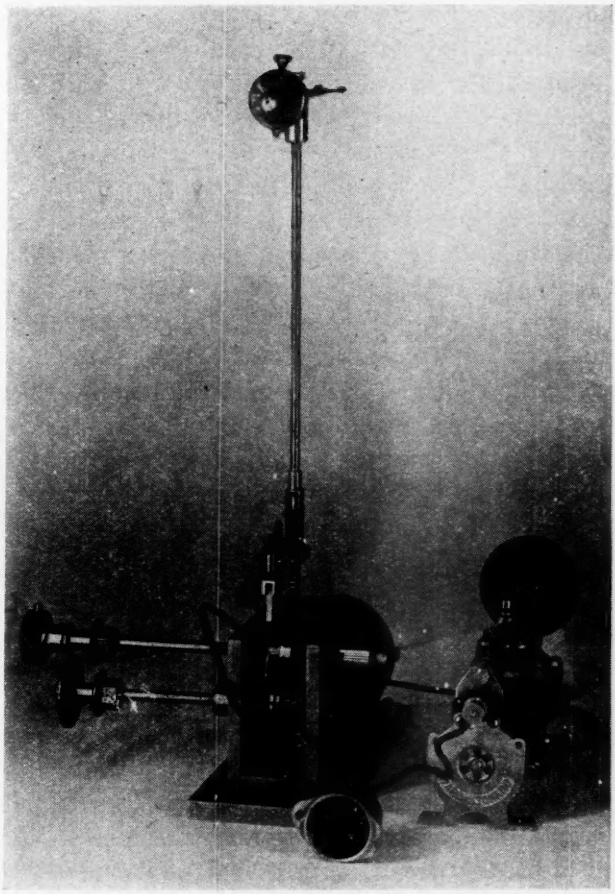

FIG. 2.

may be placed. The instrument rests upon a mahogany box, in which is mounted a standard form of variable electrical resistance and a small high-speed motor. The latter, by a suitably designed gear train, is made to give motion to a rising and

falling slide rod near the rear of the box (see Fig. 2). From this slide rod a horizontal arm reaches forward, and, by means of split fingers, supports the scale pan and ram. The weight of the moving parts at the front of this arm is counter-balanced by a circular weight and set-screw near the rear. This avoids cramping in the slide rod and imposes a fairly definite weight upon the motor and gearing below.

The normal speed of the motor is 2300 R.P.M. By means of the gearing this is reduced to a speed of the slide rod of 12 ins. per minute. In this manner, the ram, presser foot, scale pan and weights are lowered at this definite velocity upon the material under measurement. Since current fluctuations in most cases would cause more or less variation in the speed of the ram, the electrical resistance is used as an adjustment to cause slight variations in the speed of the instrument so as to bring it to the desired 12 ins. per minute. The motor train contains a small fly wheel which steadies the rotation, and is accompanied by an automatic clutch which throws itself out of gear when the slide rod has reached the bottom of its stroke. At the right of the box is a knurled handle, ratcheted to prevent reverse rotation, whereby the slide rod and moving parts may be lifted up about ½ in. for the introduction of material under the foot. This, of course, is carried out while the motor is running and the clutch is out of engagement.

Low down upon the right-hand side is a speed indicator consisting of a dial and finger so arranged as to indicate the precise speed of the moving parts. When this finger makes one revolution upon the dial in 12 seconds, the machine is so geared as to give a precise foot velocity of 12 ins. per minute. The motor is attached to a lamp socket and runs all the while. When the clutch is out of gear, the foot is lifted by the knurled hand-wheel to a high position, and the fabric is introduced. A further movement of the knurled hand-wheel throws in the clutch which, after a short interval, will pick up and cause the slide rod to lower the foot, ram, scale pan, etc., upon the fabric, and then to withdraw to the bottom of its stroke out of the way, leaving the above weights upon the fabric. This results in a very uniform and easily obtained thickness measurer from which the human equation is practically eliminated. By means of the

finger clamp and glass rod at the front of the box, a definite amount of tension, as suggested previously, may be applied, either to fabrics or to yarns. The clutch is very soft in its operation, and is thrown out of engagement without perceptible jar or motion.

The author has used this device upon a large number of thickness measurements and has been able to duplicate results with ease and precision. Table 1 gives the results of 10 measurements on each of four different fabrics.

The construction of this apparatus is neither expensive nor complicated. To the author's knowledge no feature of it has been patented. Any laboratories desiring to construct a measurer of this type for their own use are at liberty to do so, and the author will be glad to co-operate in every way to this end. If the stipulations tabulated at the beginning of this article are carried out, and apparatus of this type is employed for thickness measurements, a large proportion of the difficulties and irregularities of such determinations will disappear.

TABLE 1

Thickness Measurements by Precision Gauge Measurer.
Mass. Institute of Technology, Cambridge, Mass.

Observation No.	Thickness, Inches			
	Fabric 1	Fabric 2	Fabric 3	Fabric 4
1	0.0159	0.0180	0.0323	0.0770
2	0.0158	0.0190	0.0327	0.0780
3	0.0159	0.0186	0.0339	0.0788
4	0.0157	0.0194	0.0334	0.0794
5	0.0156	0.0186	0.0330	0.0763
6	0.0158	0.0196	0.0342	0.0774
7	0.0159	0.0194	0.0328	0.0750
8	0.0155	0.0192	0.0329	0.0776
9	0.0156	0.0189	0.0343	0.0793
10	0.0158	0.0186	0.0327	0.0803
T.	0.1575	0.1893	0.3322	0.7791
A.	0.0158	0.0189	0.0332	0.0779

NOTE: Fabric 1.—A well-woven and uniform 2/60s mercerized cotton Wing Fabric.
Fabric 2.—A heavily starched and rather irregular Book Super.
Fabric 3.—A standard figured Automobile Upholstery Fabric.
Fabric 4.—A fairly heavy Punched-Felt, not very uniform in any of its characteristics.

Textile Foundation Studies

THE RESEARCH WORK of two more Fellows of the Textile Foundation has been explained in as non-technical language as possible, and released for publication. These stories, which are reproduced here in large part, cover the work of O. W. Pineo on "The Spectrophotometric Analysis of Dyed Materials," and of D. J. Salley on "Protective Effects in Textile Deterioration and Dye Fastness."

Prevention of Textile Deterioration

NOT only the appearance, but also the quality of cotton and other textile fabrics of cellulose base are jeopardized by exposure to light and heat, states Textile Foundation Research Fellow D. J. Salley, who is investigating the problem at Frick Chemical Laboratory, Princeton University, under the direction of Dr. H. S. Taylor. A 10-degree increase of temperature may double the rate of deterioration, and the ultra-violet rays of sunlight are also particularly devastating, he states in a progress report on his study of "Protective Effects in Textile Deterioration and Dye Fastness."

In addition to studying the exact action on the cellulose structure of textiles by light and heat, Mr. Salley's research is planned to discover the influence of various foreign substances added in textile manufacture that may hasten the rate of deterioration. The exact influence of such materials will be demonstrated for the practical purpose of enabling manufacturers or processors to prevent or minimize the condition where possible.

Another angle of the investigation, Mr. Salley explains, is to determine whether other substances may be employed to counteract the destructive effect of light and heat. He cites the instance of rubber, in which "anti-oxidants" are incorporated to combat the natural deterioration of aging.

Mr. Salley's report adds: "Chemical processes accelerated by light fall in a class known as photochemical reactions. The deterioration of textiles on exposure to sunlight clearly illustrates that condition.

"Some photochemical reactions result from light arousing only one particular molecule, but in other cases the light energy stirs a number of different molecules. These latter cases, called 'chain reactions,' are sometimes caused or aggravated by the presence of added substances which act as catalysts. Traces of iron or copper salt, for example, accelerate reactions in many oxidation processes.

"Conversely, the presence of small amounts of different foreign substances, usually some organic compound, may sometimes greatly decrease the rate of reaction. Such inhibitors serve to break the reaction chain at some stage. The use of 'anti-oxidants' to forestall the aging of rubber is a case in point.

"In order to devise a method to prevent or minimize textile deterioration from photochemical reaction, our research will seek to ascertain the exact course of the oxidation process. The problem is particularly complicated because of the complex structure of the cellulose molecule which goes to make up the textile fiber. Simpler substances, related to cellulose, are being investigated first so that the manner of their oxidation may be applied in the search for a control of textile oxidation."

Spectrophotometric Analysis of Dyed Textiles

MACHINES which perform the functions of the eye and brain in color-vision have been developed in the Color Measurements Laboratory at the Massachusetts Institute of Technology and are being applied to textile color problems by Professor Arthur C. Hardy and O. W. Pineo, a research Fellow of the Textile Foundation. The Spectrophotometric Analysis of Dyed Materials is a broad description of the research work of Mr. Pineo.

Describing and illustrating his work, Mr. Pineo goes on to say that if some skilled surgeon were to install in the human brain some little meters to measure the color-sensation, many of the perplexing color problems of the industry would be well on the road to solution. This would be the most direct and powerful method of attack, because our interest in color lies in its effect on us as observers, and the meters would overcome the present lack of a yardstick with which to measure and rationalize this effect.

The memory is very poor for colors and even samples change with time, but the vast amounts of practical experience which are now wasted because we cannot describe and preserve the results of our experiments might be saved through meter readings systematically filed. A yardstick for color would make possible accepted limits to settle the frequent divergencies of opinion on matches and to grade the ability of textile materials to withstand exposure to sunlight and laundering. More fundamentally, a numerical specification of colors would lend itself to study of their origin, their dependence on dyeing processes and dye concentrations, and to further investigation of the physiology and psychology of color vision.

Of course science can not at present measure with meters the color excitation in our brains, but it can perform with other means than eyes and brains all the essential processes of color vision and measure the results. This requires the collaboration of both the physicist and the psychologist.

The physicist says that light, the agency producing the sensation of color, is a wave motion and that all colors are made up of the spectrum colors, which are fundamental and differ from each other only in the frequency of their vibration. By means of a prism the light coming to the eye from a "colored" object can be separated into its fundamental constituents, and a spectrophotometric curve showing the amounts of each is a complete description of the "color" from the point of view of the physicist, but obviously it says nothing about what the color *looks like*.

To determine the appearance of a color the psychologist demonstrates that any stimulus whatever falling on the eye can be matched by three arbitrarily chosen primary stimuli when added together in the proper amounts. If two colors are matched by the same amounts of the primaries they look alike, even if their spectrophotometric curves are different, which is often the case; and, if by different amounts, they look different.

The three numbers giving the amounts of the primaries to match a given color are the meter readings that are desired, and they can be gotten from the spectrophotometric curve furnished by the physicist. The amounts of primaries are known which match unit amount of each of the physicist's fundamental constituents: the spectrum colors. By simply adding up the

amounts to match the constituents separately one gets the amounts to match the whole stimulus. This computation can be done mathematically with the help of an integraph. The choice of primaries has been internationally standardized, so that the result of the color determination is three numbers which *define* what the color *looks like.*

This process of determining the spectrophotometric data and integrating it is the analogue of vision and answers directly the question "Do these look alike or different and how much?" Yet the "seeing" is done by an integraph which is not subject to the wide variations of color vision which exist from person to person, since it incorporates internationally standardized average data insuring consistent results in different laboratories.

The measurement of color in this way has hitherto been handicapped by the labor necessary to obtain the spectrophotometric curve and perform the computations, since only a few samples could be measured in a day. But the recent development of integraphs and of rapid and accurate spectrophotometers at the Massachusetts Institute of Technology make possible its application in the work of the Textile Foundation on the many color problems of the textile industry.

"An Invaluable Reference Work"

"The December issue of *The Chemist* carried an account of the annual meeting of the U. S. Institute for Textile Research, Inc. The volume under review shows even more graphically than do the addresses at that meeting how great has been the need for such an Institute and how competently the need is being filled. The chapter headings illustrate the broad subdivisions of textile knowledge; and the authors of the seperate chapters, each a specialist, supply excellent summaries of the knowledge in their fields.

"As an instance worthy of special note we have the chapter on Chemical Analysis by our fellow-member, Dr. Joseph F. X. Harold. In the twenty-five pages of this chapter are covered all branches of the textile industry. Reference is made to 160 different publications on the subject.

"As an example of thorough workmanship, and as an invaluable reference work for the textile chemist or engineer, the book is highly recommended."—Karl M. Herstein in *The Chemist,* Jan., 1933.

X-Ray Analysis of Fibres:

Part I, Literature Survey

By WAYNE A. SISSON

Mr. Sisson is a senior research fellow of The Textile Foundation, and his studies on this subject are being conducted at the University of Illinois, Urbana, Ill., under the direction of Dr. George L. Clark, who is a noted authority on X-ray research.

The Textile Foundation had not provided for the publication of Mr. Sisson's literature survey, but it was considered so complete and valuable to research workers in this field that TEXTILE RESEARCH *decided to publish it in two installments, after it had been released for such publication by The Textile Foundation.*

Introduction

IN ORDER to prevent needless repetition of past work and to acquaint ourselves with the published data relating to the x-ray work on textile fibres, it was thought advisable to make a thorough survey of the literature on this subject before starting experimental work. Although the x-ray work on cellulose was started only fifteen years ago, the literature in this field has already reached voluminous proportions.

All of the articles relating to x-ray investigations on cellulose and other textile fibres have been abstracted and catalogued. This task has occupied over half of our time during the first six months of work.

The articles included in this report have been limited to those which deal wholly or in part with the results obtained from x-ray studies on the structure of cellulose and other textile fibres. A short abstract of each article relating to the various topics investigated is presented in chronological sequence, in order to stress not only the progress and importance, but also the comprehensive nature of the x-ray work on this subject during the past few years. It is hoped that this survey in its present form may be of interest or help to other investigators who are working in this and related fields of research.

Before 1920

Crystallinity of Cellulose

It had been known for some time from optical data that cellulose fibres were anisotropic, but no definite theory regarding the structure had been proposed until 1858 when Nägeli [1,2] advanced his micelle theory. He postu-

lated that all cellulose fibres were built up of submicroscopic anisotropic crystalline particles which he called micelles. Although this theory was not accepted at that time, Nägeli was able to explain many properties of cellulose which could not then be explained by any other theory. The fact that cellulose is crystalline was first demonstrated by Gilson [3] in 1893 and later confirmed by Johnson [4] in 1895 with the use of polarized light.

First X-ray Work

Eighteen years later the crystallinity of cellulose was first confirmed by means of the x-ray, and although reference is very seldom made to the article, this first result of an x-ray examination of cellulose materials, which we have on record, was reported by Nishikawa and Ono [5] in 1913. They were interested in comparing the type of x-ray patterns obtained from fibrous, lamellar, and granular substances. They described the symmetrical pattern obtained from asbestos fibres, mounted perpendicular to the x-ray beam, and reported that some organic fibres, such as silk, wood and bamboo, gave somewhat similar pictures. However, these "fibre patterns" blended into continuous rings when the fibres were powdered sufficiently fine.

The next year Nishikawa [6] published a paper explaining the type of x-ray pattern obtained from fibre materials. He reasoned that any substance which gave a "fibre pattern" should consist of a number of elementary crystals of a definite structure arranged parallel to the fibre axis. This structure should play the same role in analyzing a beam of x-rays as the method of rotating a single crystal described by de Broglie.[7] Although the cellulose x-ray patterns obtained in this investigation were not very clear, their interpretation was essentially correct, and proved to be several years ahead of the general advancement of the knowledge concerning the structure of fibrous materials which later developed in Germany.

Early Work by Scherrer

After Debye and Scherrer [8] had developed the method of x-ray analysis of pulverized substances, Ambronn [9] in 1917 predicted that if cellulose was a crystalline material it should give a line diagram with monochromatic x-rays. Acting upon this suggestion, Scherrer [10] investigated cellulose with x-rays, but reported that cellulose gave an amorphous pattern. However, he later repeated the work on ramie cellulose and obtained a definite crystalline pattern in 1918.[11] Scherrer concluded from these patterns that cellulose was a definite crystalline substance and that the micelles must be parallel to the fibre axis.

1920

Early Work at Kaiser-Wilhelm Institut

In the meantime Herzog and Janeke at the Kaiser-Wilhelm Institut für Faserstoffchemie, began an x-ray investigation of cellulose fibres which later proved to be the beginning of a long and important series of investigations, which have contributed much to our present knowledge concerning the structure of cellulose fibres. Their first results were published in the fall of 1920.[12] In this first note they showed that cellulose, when

examined by the method of Debye and Scherrer, had a definite crystalline structure which they reported as rhombohedral, and that the structure was the same regardless of the material from which it came. In a later more complete paper [13] they give the axial ratio of the rhombic crystal as 0.6935:1:0.4467. Cellulose from cotton, ramie, wood, flax, jute and linen all gave identical powder patterns. If a parallel bundle of ramie fibres were used instead of a powder, a fibre pattern similar to that for a cold drawn wire was obtained. Artificial silk and viscose gave a crystalline pattern similar to cellulose, but differed in that parallel fibres gave concentric circles. They reported artificial silk from acetyl cellulose, hair and wool to be amorphous. They showed that lignified wood gave a cellulose pattern which indicated that lignin was adsorbed on the surface of the cellulose crystals and not chemically bound. In another publication [14] the type of pattern obtained from a parallel bundle of fibres inclined at various angles to the x-ray beam is discussed.

Thus the year 1920 proved to be an epoch year in the history of the development of the x-ray examination of cellulose fibres.

1921

Fibre Patterns

In 1921 Polanyi began publishing a series of papers relating to the interpretation and significance of the x-ray fibre diagram. Two papers [15, 16] with special reference to the fibre structure of cellulose appeared.

Structure of Cellulose

Herzog [17] contributed further data regarding the structure of cellulose by giving 680 x 10–24 cm. as the probable volume of the elementary parallelepiped, and stated that if this were true, the groups ($C_6H_{10}O_5$) must be repeated regularly. The symmetry of the rhombic crystals may be represented in the cellulose molecule; however, the monoclinic system was not excluded. He suggested three possible types of structure: (1) Open chains of dextrose residues linked together in groups of four in series by means of oxygen bonds, (2) closed rings of dextrose components linked by oxygen bonds, or (3) internal anhydrides. If the rhombic symmetry is correct then the dextrose residues must be linked in pairs by oxygen bonds connected to the second and sixth carbon atoms.

Unit Cell Dimensions

Polanyi,[18] in an address before the Kaiser-Wilhelm Institut, gave the unit cell dimensions of cellulose as 7.9 x 8.45 x 10.2 Å., and calculated that such a unit contained room enough for four glucose groups. This appears to be the first data published on the size of the unit cell to be accepted by later investigators. Polanyi also suggested two possible structures for cellulose.

Herzog and Jancke [19] published the results of an x-ray investigation on a large number of organic compounds including cellulose.

Radiography

Truesdale and Hayes [20] investigated the possibility of radiographic examination of textile materials. They used lead chromate to make the fibres opaque to x-rays. There is little advantage to be gained by the radiographic examination of textiles and as a result this type of work has not been continued.

1922

Very little literature relating to the x-ray structure of cellulose was published during 1922; however, two definite contributions were made.

Fibre Diagram

The theory of fibre diagrams, with special application to plant fibre diagrams, was further developed by Polanyi and Wissenberg [21] in a series of three papers published during the year.

Sponsler

A paper on the structure of the starch grain [22] marked the first appearance of Sponsler's pioneer x-ray work. This paper is mentioned here because it was the beginning of a continuous series of investigations, carried out at the Southern Branch of the University of California, which have contributed important x-ray evidence toward the solution of the fundamental structure of cellulose.

1923

Cellulose Structure

Herzog [23] reviewed some of his previous results and in addition stated that the crystals in artificial silk lie in all possible directions. The strength and degree of swelling of cellulose fibres are dependent upon the crystal arrangement. A long paper on the chemical and x-ray evidence for the structure of cellulose was given by Hess and his coworkers.[24] They showed that the alkali soluble portion of hydrocellulose gave the same x-ray pattern as normal cellulose.

Starch and Cellulose

Sponsler [25] published a further paper on an x-ray study of the structure of starch, and worked out a model to fulfill the necessary requirements of the x-ray diffraction pattern. He states that cellulose also consists of a regular arrangement of $(C_6H_{10}O_5)$ groups with the spacings 6.14 x 6.14 x 5.55 Å.

Silk

Brill [26] carried out the first extended x-ray study on the structure of silk fibroin. The x-ray study showed silk to be composed of at least two proteins, of which one is crystalline. He examined nine different samples

of silk and in each case the crystallites were found to be embedded in a cementing substance, and orientated with a crystal axis approximately parallel to the fibre axis. He suggested a possible structure for silk.

1924

The year 1924 is important because it marks the beginning of the application of x-ray research to the problems of cellulose chemistry, such as mercerization, hydrolysis, etc. During the remainder of our review we will divide our discussion into two parts: (*a*) STRUCTURE and (*b*) CHEMICAL REACTIONS. A discussion of the x-ray work on the chemical reactions and the resulting substitution products is included because much information may be obtained concerning the structure of cellulose fibres from their behavior toward chemical reagents.

(*a*) Structure

Gonell [27] discussed the x-ray diagram obtained from fibrous cellulose and concluded that cellulose must consist of more than one crystalline substance. A further paper on the structure of fibrous materials was published by Katz.[28] Sponsler [29] studied the type of x-ray diffraction patterns obtained from vegetable fibres, and pointed out that the blurred lines produced from cellulose must be due to the small size of the crystallites.

Plant vs. Animal Cellulose

Herzog and Gonell [30] compared the x-ray pattern of tunicin with cellulose from plant fibres and found them to be the same. Lichenin gave a slightly different pattern than cellulose; however, both give the same hydrolytic products. The x-ray comparison of plant and animal cellulose (tunicin) proved to be of considerable interest and confirmed the results of chemists who for a long time had known that the two celluloses gave the same chemical reactions.

Artificial Silk

Definite diffraction lines were obtained from artificial silk by Herzog and Gonell,[31] who withdrew their earlier statement [13] that artificial silk was amorphous. With the exception of "acetate silk," the patterns appeared to be identical with mercerized cellulose.

(*b*) Chemical Reactions

Mercerization and Hydrolysis

Herzog [32] gave a review of the past work on the crystalline structure of cellulose and chitin, and pointed out that when cellulose is treated with concentrated NaOH under tension, it shows a different diagram from the original cellulose. Physical effects of mercerization do not parallel the x-ray changes, although x-rays can be used to follow this process. X-rays show no changed pattern upon hydrolysis of cellulose unless the process is carried out under tension. Since mercerization slightly increases the lattice constant but not the density, Herzog reasoned that there must be a chemical rearrangement in the molecule without an increase in molecular size.

Swelling

In the first of a series of papers on the chemical treatment of cellulose, Katz [33] discussed the application of x-rays to the study of the mechanism of the process of swelling. He was the first to point out the important fact that the spacings obtained from x-ray data are smaller than the distance between the centers of the molecules themselves, due presumably to the atomic groupings in the molecule. Thus it may not be possible to detect the swelling process with x-rays, since the liquid enters between the molecules instead of penetrating them.

1925

The year 1925 marks a still greater advance than 1924 in the application of x-rays to problems relating to the effect of chemical reagents upon cellulose. However, at the same time, definite progress was also made on the fundamental structure of cellulose.

(*a*) Structure

Polymerization

One of the greatest advances of the year was contributed by Herzog [34] when he showed that in the molecule $(C_6H_{10}O_5)_n$, n may be indefinitely great, or n may be 1, 2 or 4. The values 3 and 5 are excluded.

Fibre Orientation

Herzog published another paper [35] setting forth the theory that tension during growth causes the orientation of the crystallites in the fibre. He supports the theory by showing that preferred orientation is more pronounced in artificial silk if tension is applied during the spinning process. He considers a cellulose fibre to be a two phase system, consisting of a crystalline and an inter-crystalline material.

Molecular Structure

Katz [36] published an important theoretical paper in which he suggested the new and important idea that the cellulose molecule may be larger than the units indicated by the x-ray data. The residual valence of these elementary cells may determine the degree of association of the cellulose particles and the strength with which they are held together.

Plant Fibres

Sponsler [37, 38] summarized his three or four years' work in the field of cellulose structure and showed that from known data the size of a $(C_6H_{10}O_5)$ group should be about 6 x 5.5 x 5 Å. He reports the distance from center to center of groups of atoms along the fibre axis to be 6.10 and 5.40 Å. The space lattice is orthorhombic and the manner in which it is laid down in the cell wall is suggested. The spacings which are obtained as the fibres are rotated at various angles to the x-ray beam are given.

(*b*) Chemical Reactions

Mercerization

Katz and Mark [39] showed that cotton mercerized in salt and acid solutions gave the same x-ray pattern as the original cotton, while alkali treatment produced a change. After the alkali is washed out the original pattern returns, but only as superimposed upon the alkali pattern. This suggests a partial reversion and the new product may be an isomer. They showed that concentrated alkali produced an enlargement of the cellulose lattice. Katz and Vieweg [40] found that swelling produced by lithium, sodium and potassium all produced the same results. There was a 4% increase in the lattice constant if greater than a 36% concentration of sodium hydroxide was used. Katz [41] published somewhat similar data in which he suggests that the changed x-ray pattern is due to the formation of an alkali hydroxide compound with cellulose. Katz and Mark [42] studied the swelling of ramie fibres in concentrated potassium iodide solutions and found that an entirely new x-ray pattern appeared with the disappearance of the original one. However, the original pattern returned when the swelling reagent was removed.

Chemical Treatment

Herzog [43] discussed the crystal structure of plant fibres and the effect of chemical treatment and purification processes. Hydrolysis does not change the lattice but produces a depolymerization. The same is true of oxycellulose and the ripening of viscose.

1926

The year 1925 marked the close of a five year period since the structure of cellulose was first investigated by x-ray methods. During that period most of the work was carried out in Europe by Herzog and his coworkers Polanyi, Gonell, Mark, and others at the Kaiser-Wilhelm Institut; and Katz at Amsterdam. A similar investigation was being carried out in America by Sponsler at the University of Southern California. Much x-ray information had been obtained but the investigators were at a loss as to its proper interpretation. However, in 1926 new ideas were conceived which acted as a stimulus to the original workers and attracted many new ones into the field.

Two outside factors were largely responsible for this renaissance. The first was provided by the progress in the field of sugar chemistry by Haworth, Irvine, Peace, and others, who succeeded in making clear the configuration of the glucose unit. The other factor was the increase in knowledge with regard to the size and shape of the molecule, contributed by the Braggs.

This fundamental knowledge, combined with the increased experience in x-ray technique, made it possible to interpret x-ray patterns more correctly and establish a reasonably accurate model of cellulose. As we shall see, Sponsler and Dore first constructed such a model, and later a more complete one was developed by Meyer and Mark.

(*a*) Structure

Lichenin

Herzog published additional data [44] relating to his original work on the x-ray comparison of lichenin and cellulose. By comparison of intensities he concluded that the x-ray diagrams of beta-cellulose and lichenin were very similar but not identical. A similar comparison of the structure of lichenin and cellulose was carried out by Ott.[45]

Oxycellulose and Hydrocellulose

Ott [45] also investigated the structure of cellulose, precipitated cellulose, oxycellulose and hydrocellulose and found them to give identical x-ray patterns.

Weighting of Silk

Herzog and Gonell [46] made an x-ray study of the nature of weighting silk and concluded that cryptocrystalline deposits were formed, and that there was not a chemical union between the weighting material and fibres.

Structure

A summary of "Recent Progress in Knowledge of Fibrous Substances" [47] was made by Herzog, in which he points out that plant cellulose or cell walls are made up of fibrillae which in turn are made of a number of parallel crystallite chains. This crystallite or small building unit is the unit revealed by x-rays. In an address delivered by Herzog [48] he gave a summary of recent advances in the x-ray examination of cellulose.

English Publication—Herzog

Herzog for the first time published in English a summary of the work done in Europe. In a paper presented before Canadian chemists [49] he stated that the cellulose cell contained four ($C_6H_{10}O_5$) groups. He suggested that the fibre structure of cellulose materials is probably due to the crystals of cellulose growing under tension along the fibre axis. He thought that the ($C_6H_{10}O_5$) groups were probably linked together according to Werner's theory of secondary valence. A more complete summary of the status of the structure of cellulose was published by Herzog in an American journal.[50] He states that the unit cell is rhombic and that the sides of the cell are $a = 8.60$, $b = 7.78$ and $c = 10.22$ Å. The quadratic equation for rhombic symmetry is given and calculated values compared with observed values. The size of the colloidal particles of cellulose of various origins and treatments are given. Mark in an address [51] gave a review of the structure of cellulose.

Bragg

The structure of cellulose as revealed by x-rays was reviewed by Bragg [52] in a lecture. This was the first article to appear in England on the x-ray structure of cellulose. In another article [53] he discussed the use of x-rays in studying long chain molecules.

Clark

Clark [54] made his first appearance in the field of x-ray investigations on cellulose by giving a discussion of the application of x-rays to textile problems. In a further paper on "X-rays and Colloids," [55] he gave a summary of the x-ray work on cellulose.

Sponsler

Sponsler had been collecting data for several years on the structure of cellulose. In 1926 he published two important papers giving his views on the subject. In the first of these [56] he set forth the important conclusion that the cellulose building unit consisted of parallel chains running lengthwise of the fibres. These chains are 6.10 x 5.40 Å. apart. This gives two ($C_6H_{10}O_5$) units within the 10.25 dimension and four ($C_6H_{10}O_5$) within the unit cell (6.10 x 5.40 x 10.25 Å.). He also points out that the chains are arranged in concentric cylinders or layers in the cell walls. This paper was important because it first pointed out that the unit cell, obtained from x-ray data, was only a part of the cellulose molecule and that the cellulose units were arranged in long chains. In another long and important paper delivered before the Fourth Colloid Symposium,[57] Sponsler and Dore attempted to correlate the spatial relation between the groups, as obtained from x-ray data, with the chemical and physical properties of cellulose fibres. They concluded that the amylene oxide ring formula was in closest agreement with the x-ray data, and that the glucose units were united in chains of indefinite lengths by glucosidal condensation, the union between units being alternately a 1–1 and a 4–4 linkage. The cellulose units are bound longitudinally by the primary valence forces and laterally by secondary valence forces. This picture accounts for longitudinal tensile strength, the longitudinal and lateral thermal expansion, and swelling phenomena. It also explains several chemical reactions.

(*b*) Chemical Reactions

Alkali-Cellulose

Katz attempted to correlate the adsorption curves and the heat developed during the process of mercerization with x-ray measurements. In another paper [59] he points out that previous explanations are inadequate to account for all the phenomena observed upon swelling cellulose with alkalies.

Acetyl- and Nitro-Cellulose

Herzog [60] studied the x-ray diagram of acetyl- and nitro-cellulose. He states that the cellulose acetate cell contains sixteen $C_6H_7(C_2H_3O_2)_2O_2$ groups and nitrated cellulose thirty-two $C_6H_8(NO_3)_2O_2$ groups, and pointed out that these were multiples of the four ($C_6H_{10}O_5$) groups in cellulose. Hess [61] showed that if Herzog's data was properly calculated the numbers were 1.6 and 3.2 respectively and suggested that the number 4 probably had nothing to do with the cellulose molecule. Herzog [62] admitted the error in calculation, but still defended his theory of 4($C_6H_{10}O_5$) groups per unit cell.

1927

(*a*) Structure

Space Lattice

Sponsler [63] discussed the agreements and disagreements between Herzog's [50] and his own [37, 38] data. Sponsler maintained that Herzog's 3.98 line is due to kβ radiation and therefore his model is without justification.

Polymers

Staudinger and his coworkers [64] pointed out that the polyoxymethylenes from formaldehyde are similar in structure to cellulose and that the x-ray study of such compounds may throw light on the structure of cellulose. Although they have different chemical properties they exhibit the same x-ray pattern. By sublimation they were able to obtain a product giving a fibrous structure similar to cellulose.

Von Veimarn [65] published theories relating to the structure of fibrous materials with special reference to cellulose.

(*b*) Chemical Reactions

Katz [67] pointed out that the treatment of several kinds of cellulose fibres with strong nitric acid gave the same change in x-ray pattern as treatment with alkalies. Herzog [68] showed that cellulose fibres which had been given the same chemical but different physical treatment gave different x-ray patterns. This suggests that hydrated cellulose may be either a physical or chemical change, probably a physically distorted though definite structure.

Cellulose Nitrate

Herzog and Von Nary-Szabo [69] pointed out that the x-ray diagrams of cellulose nitrate prepared in different ways were the same. They conclude that cellulose nitrate is a mixture of cellulose trinitrate and unchanged cellulose. The elementary cell contains four molecules, and its dimensions are a = 14.75, b = 7.88, c = 10.30 Å.

1928

After a year of relative inactivity, 1928 marks the culmination of past data resulting in a conception of the structure which has changed very little even up to the present time.

(*a*) Structure

Herzog and Jancke published five papers during 1928 relating to the structure of cellulose. They examined [70] several special bast fibres showing negative double refraction but found no new identity period. By using a large plate distance (10 cm.) they claimed [71] to have found a new line very close to the central beam corresponding to a lattice spacing of 35.3 Å.

They were also able to detect a weak spot corresponding to 16 Å. In a long important historical and theoretical discussion of the structure of cellulose[72] they examined natural and hydrated fibres and concluded that natural cellulose belongs to the monoclinic and the hydrated to the rhombic system. They found that the slope of spirals in plant fibres as determined by x-ray analysis agreed with the values obtained from microscopic data.

Is There Only One Cellulose?

Gonell had previously examined[27] several types of cellulose fibres and concluded, from the fact that the diffracted spots were split, that cellulose was composed of more than one component. Herzog and Jancke[73] showed this splitting to be due to the experimental setup and not to distortion or a second component.

Deformation of Fibres

Herzog and Jancke[74] examined, by means of x-ray patterns and microphotometer curves, mercerized cellulose and natural silk deformed by rolling and pressing.

Reviews

Cassal and Rolland published two articles[75, 76] reviewing the important results of x-ray investigations on cellulose fibres and their suggested applications to textiles and cellulose derivatives.

New Structure—Mark and Meyer

Two very important papers appeared during 1928: One on "The Structure of Crystallized Components of Cellulose" by Meyer and Mark[77] and the other a general review of the new theories applied to organic polymers by Meyer.[78] Because of the great importance of these papers we think it justifiable at this point to consider their contents in more detail.

The paper by Mark and Meyer[77] reviews the whole subject of cellulose and its derivatives. They conclude that cellulose contains a crystalline component having the dimensions $a = 87$, $b = 10.3$, $c = 7.8$ Å., and $\beta = 90°$. b is the edge of the cell parallel to the fibre axis. The most probable space group in the monoclinic system is C_2^2 and the unit cell contains 4 glucose residues. These residues are not separate as in a molecular crystal, but are joined together to form a continuous linkage in the fibre axis direction (b) so as to form long chain molecules held together at the sides by ordinary molecular forces. The following model is discussed in the light of x-ray results and chemical considerations:

Five carbon atoms and one oxygen atom form a hexose ring with a 1:5 linkage. Two hexose rings are joined to form cellobiose by linkage through an oxygen atom, which in turn joins No. 1 carbon of one ring to No. 4 of the other ring. The C–C distance is 1.5 A. U., the C–O distance 1.2 A. U. and the length of the two joined rings is 10.3 A. U. The cellobiose residues are thus joined by an O bridge from unit cell to unit cell, the axis of the chain thus formed being the fibre axis. Mercerization, nitration and other chemical properties do not affect the structure essentially, but only alter the cell size and change the relative intensities of re-

flection. This is because the substituent groups attack only the sides of the chains without breaking the chains themselves.

Cellulose is not composed of molecules in the usual sense, but particles or micelles made up of cellobiose chains arranged in parallel and held together by inter-micellar forces, which are similar in nature to Vander-Waal forces. The great tensile strength in the fibre axis direction of cellulose fibres is due to the primary valence structure of the cellobiose chains. The strength in the lateral direction indicates a strong inter-micellar force, as might be expected from the length of the chain and strong attraction of OH groups.

The chains are not necessarily all of the same length. From the breadth of the x-ray interference lines and diffusion coefficients Mark and Meyer estimate that there are about 1500–2000 glucose residues per micelle. This gives from 40 to 60 subcellobiose chains each having 30 to 50 glucose residues. No definite conclusions were reached concerning the form of the crystallite but it was shown that they were easily orientated and must be oblong.

Hess and Trogus [79] opposed the conception of the structure of cellulose as advanced by Mark and Meyer. They argue that the structure of cellulose deduced from x-ray diagrams is rendered difficult and invalid by ignorance of the corresponding diagrams of carbohydrates of known structure. They claim to have isolated a biasan ($C_{12}H_{20}O_{10}$) from cellulose which differs but little from cellulose in the mass distribution of its constituent atoms. Hess and Trogus think that a model with greater mass concentration explains more closely the present knowledge of cellulose than that advanced by Sponsler and Dore [57] or Meyer and Mark.[77] Meyer and Mark defended their views in a later paper.[80]

It is interesting to note that many of the features of Mark and Meyer's cellulose structure are similar to those advanced at an earlier date by Sponsler and Dore.[57] Both authors agree on long primary valence chains of the glucose units, but disagree on the positions of the linking atoms and the dimensions of the unit cell. Mark and Meyer's conception of the micellar structure was essentially new and explained many physical and chemical properties such as viscosity and other properties of cellulose in solution.

Structure—Sponsler

Sponsler [81] published a note claiming that Herzog's interpretation [50] of the space lattice of cellulose was false for several reasons. In another paper [82] he discusses the general agreement and disagreement of some of the details of his views with those of European investigators, and points out the difficulties and limitations of x-ray analysis of cellulose structure. A summary of his work and a very interesting discussion of the x-ray determination of cellulose in the cell walls was given by Sponsler in a later paper.[85]

Micelle Theory

Mark [84] discussed the micellar structure of cellulose and reviewed the use of the optical and x-ray methods for the examination of micellar structure. In another paper Hengstenberg and Mark [85] discussed the Laue method for the determination of the form and size of small particles. Their

investigations on cellulose and artificial silk show micelles elongated parallel to the fibre axis, with the average thickness of about 55° A. U. and a length of over 600° A. U. From photographs taken at the temperature of liquid air it was found that the coefficient of expansion for the direction parallel to the fibre axis is considerably smaller than at right angles to the axis.

Wool

Threadgold [86] examined several woolen samples by x-ray diffraction methods, and came to the conclusion that there was no evidence for assuming a crystal structure in wools. If a crystal structure exists it must be in form of extremely minute colloidal crystallites which are individually too small to give a characteristic x-ray diffraction pattern.

Silk Fibroin

Analogous to their theory on the constitution of cellulose,[17] Mark and Meyer [87] visualize silk as consisting of four principal valence chains which correspond to a polypeptide of at least 20 glycyl-alanyl residues. This explains the original results of Brill.[26] They discuss the possibility of rhombic and monoclinic symmetry, but point out that in silk a greater number of assumptions are required than in cellulose, because the spiral axis is lacking. Herzog [88] discussed the possibilities of the cellulose molecule, as determined by x-ray analysis, in its application to artificial silk.

Wood Cellulose

Hess, Ludkte, and Rein [89] examined 14-day-old beech shoots and compared the x-ray pattern with the heartwood of a 385-year-old tree and found the cellulose rings for the two to be identical. They point out that the crystallites are less uniformly oriented in young wood than in old.

Dyed Cellulose—Theory of Dyeing

Bion [90] attempted to decide by means of x-rays whether the particles of a dye or metal precipitate on a fibre are deposited with a random or preferred orientation, and whether they are combined chemically with the fibre or adsorbed on it. He found that most salts were deposited as unorientated crystals. Organic dyes did not give sharp rings. It is therefore most probable that they were adsorbed. From the breadth of the x-ray lines he concluded that coagulation takes place in the process of dyeing. Meyer [91] claimed that the difference in affinity of the various commercial cellulose fibres toward direct dyestuffs was explainable on the basis of the internal structure of the fibres as revealed by x-ray analysis, as well as the shape and dimensions of the dye molecule.

Adsorption of Salts

Aborn and Davidson [92] studied the x-ray structure of salts adsorbed on cellulose and found below a certain concentration the salt was molecularly or ionically dispersed, while above that concentration crystals of salt existed as such.

(*b*) Chemical Reactions

Review

Trillat published two papers [93, 94] reviewing the structure of natural cellulose from various materials and the transformation of cellulose under the influence of various reagents. He states that hydra-, hydro-, and oxycellulose can exist in two forms: native and mechanically deformed cellulose. Cellulose, oxycellulose and hydrocellulose give identical diagrams except that different orientations are observed. The process of acetylation was also studied. Trillat published two other papers [95, 96] on the structure of cellulose and cellulose acetates and reports the findings of a 1.2 A. U. spacing. Oxycellulose and hydrocellulose give patterns having random arrangements. Many other topics are discussed.

Cellobiose Anhydride

Bergman, Herzog and Janeke [97] pointed out that the x-ray diagram of cellobiose anhydride was identical with that of hydrated cellulose; also that the diagram of hexacetate was identical with that of cellulose triacetate.

Mercerized Cellulose

Sponsler and Dore [98] obtained x-ray data on ramie cellulose which had been subjected to mercerization with various strengths of sodium hydroxide solutions. Below a critical concentration of about 13% the fibres remained unmercerized. They found that the c axis remained unchanged while the a and b were enlarged. They interpret this to mean that the chains of glucose units have been shifted latterly in the wall of the fibres and have remained unbroken. Trogus [99] attempted to correlate x-ray microscopic and chemical studies on normal and mercerized cellulose and artificial fibres.

Nitrocellulose and Acetylcellulose

Náray-Szabó and von Susich [100] gave the identity period along the fibre axis for nitrocellulose as 26.6 A. U. and for acetylcellulose as 10.3 A. U. The x-ray diagrams indicate different degrees of esterification, since a well defined lattice is only obtained for acetylcellulose with a completely substituted product.

Andress [101] made a study of cellulose treated with concentrated nitric acid and reported the nitrated product as belonging to the monoclinic system with the cell dimensions $a = 12.20$, $b = 10.28$, and $c = 9.73$ and $\beta = 53°$. He concludes that the addition of nitric acid to cellulose is accompanied by the enlargement of the lattice in one direction.

(*To Be Concluded in April Number*)

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(To Be Concluded in April Number)

Directors' Quarterly Meeting

THE regular quarterly meeting of the Board of Directors of U. S. Institute was held at the Chemists' Club, New York City, Feb. 9th. In the absence of the President, who had left for the South a few days previously, Philip A. Johnson presided.

The greater part of the meeting was devoted to routine discussion and action upon reports presented, particularly those covering membership work, the monthly magazine and the book, "Textile Research: A Survey of Progress."

Plans were outlined for more active membership work, in which it is hoped to have the cooperation of members. Because of unexpected demand from non-members for magazine subscriptions, and because the old subscription rate was considerably less than cost, the price per volume and year to non-members was advanced to $5.00, and the rate for extra subscriptions to members was raised from $2.00 to $2.50, to comply with postal regulations. Sales of U. S. Institute's book were reported to be close to the 1,000 copy mark, but, nevertheless, small for a volume of such merit.

The resignation as a director of P. H. Hanes, president of the P. H. Hanes Knitting Co., Winston-Salem, N. C., was regretfully accepted. Mr. Hanes is an original contributing member, and has served on the Board since the organization of U. S. Institute, but, because of inability to attend meetings, he felt that he should resign in favor of someone who can serve more actively. E. W. France, director of the Philadelphia (Pa.) Textile School, succeeds Mr. Hanes for a term expiring in 1935.

Progress reports were submitted by several of the Research Committee's sub-committees, but more detailed reports of work in progress will await a meeting of this committee that is tentatively scheduled for March 30, in Washington, D. C.

It was voted to accept the invitation of the Textile Section of the New York Board of Trade to appoint a representative on that organization's textile shrinkage committee, and H. Grand-

age, vice-pres., Clark Thread Co., New York City, was appointed to act for U. S. Institute.

New Members

The following new members were elected:

Edward Bohl, Jr., East Paterson, N. J.

Arthur Eichler, New York, N. Y.

The Foxboro Co., Foxboro, Mass., auth. rep., Albert W. Chase.

Nehemiah Gitelson & Sons, New York, N. Y., auth. rep., M. Leo Gitelson.

Mary Anna Grimes, Texas Agricultural Experiment Station, College Station, Texas.

Amy L. Howe, Head, Clothing & Textiles, Purdue University, Lafayette, Ind.

Alex. Smith & Sons Carpet Co., Yonkers, N. Y., auth. rep., A. G. Ashcroft.

Southern Dyeing Co., Inc., Burlington, N. C., auth. rep., James Lee Love, Pres. & Treas.

George E. Spofford, Treas., Edwards Mfg. Co., Augusta, Maine.

Lillian Stevenson, Dept. of Home Economics, University of Chicago, Chicago, Ill.

Dr. A. C. Whitford, Alfred, N. Y.

Personals

Douglas G. Woolf, Editor of Textile World and a Charter Member of U. S. Institute, succeeds Evans Clark, Director, Twentieth Century Fund, Inc., as a member of the Committee on Economic Research.

Edward R. Schwarz, Assistant Professor of Textile Technology at M. I. T., of Cambridge, Mass., a Charter Member of U. S. Institute and Chairman of its Committee on Abstracts and Bibliography, which committee is also the Board of Editors of TEXTILE RESEARCH and its other publications, has been accorded the honor of election as a fellow (F.T.I.) of the Textile Institute, Manchester, Eng. It is a recognition of his many contributions to textile research and technology, and also of a progress report of his work on "The Micro-analysis of Yarn Structure," recently accepted by the Journal of the Textile Institute.

Economic Research Survey

U. S. I. Committee on Economic Research Seeks Additional Data

IN its development of a program that will cover the most important economic problems faced by the industry, the Committee on Economic Research of U. S. Institute, aided by the advice of authorities within and outside of the industry, has selected four major subjects, and is now undertaking a survey designed to make available reports of work accomplished and in progress on these subjects. With this end in view the committee makes the following report and appeal:

The Information Sought

"In its preliminary report[1] the Committee on Economic Research of the United States Institute for Textile Research, listed some sixteen subjects.

"In response to a request for comment and suggestion, every single one of these subjects was stated to be interesting to one or more of those communicated with.[2]

"The subjects which are mentioned most frequently as being considered important were the following:[3]

"I.—Balancing and Stabilization of Production and Sales. Case Study of the Best Practice.

"A clear understanding of the best practice in dealing with this matter is of vital importance to the industry, for it affects stability of prices, stability of employment, general financial policies, etc. Such a study would involve consideration of possibility for forecasting demand through close cooperation with representatives of each of the chief factors in the channels of distribution from mill to consumer.

"II.—Selective Distribution.

"This subject involves a study of the distribution of textiles through exclusive distributors, for a territory, or class of trade, or product. It should include a study of the types of product for which this form of distribution has proved most successful. It should also take into consideration the other conditions for success and the obligations undertaken by both parties to the arrangement.

"III.—Pricing and Price Policies.

"This study would involve such matters as quantity discounts, seasonal rebates, policies as to terms and cancellations, cooperative exchange of price information, differentials to different classes of trade. It would analyze existing practices and results and attempt to find the basis for a sounder policy than now exists.

"IV.—Cost Methods in Production and Marketing.

"This should include a consideration of best practices for figuring costs—marketing as well as production. It would presumably include studies of costs of selling to different types of customers and classes of trade, and for different kinds of products.

"The committee will greatly appreciate your advising them what you have done, or are doing, and what you know others have done, or are doing, in research on any of these subjects.

"By research we mean the recorded thinking and study leading to an expressed statement of a conclusion, or of a principle, or of a natural law, or of a recommendation. To illustrate the above definition: We would define research, not so much as an article that might be written, outlining what an individual company has done along a certain line, but, rather, the analysis of the problem as a whole, possibly with ease illustrations and the drawing of conclusions or generalizations as to principles of one kind or another."

Signed, *Committee on Economic Research*
H. V. R. Scheel, *Chairman*,
233 Broadway, N. Y.

F. S. Blanchard
Paul T. Cherington
Stanley B. Hunt
E. Kent Mitchell
D. G. Woolf
A. W. Zelomek

References

1. Textile Research, Nov., 1932, P. 27–31.
2. *Ibid.*, Nov., 1932, P. 32–41.
3. *Ibid.*, Dec., 1932, P. 117–19.

Personals

H. V. R. Scheel, Vice-President, Director and Chairman of the Committee on Economic Research of U. S. Institute, is now engaged in consulting work, specializing on textile problems, with offices in the Woolworth Building, New York City.

Frank D. Cheney, of Cheney Bros., silk manufacturers, New York City, has been appointed by President Hoover to succeed Henry B. Thompson, President of the U. S. Finishing Co., New York City, as a director of The Textile Foundation. Mr. Thompson's resignation was made necessary by pressure of his other activities. Mr. Cheney has been a leading exponent of scientific and economic research. During the world war he served as a member of the Dye Advisory Committee of the War Trade Board, and as a member of the Connecticut State Council for Defense.

Abstracts and Bibliography

This section is compiled under the direction of the Committee on Abstracts and Bibliography: Prof. E. R. Schwartz, Chairman, Dr. W. E. Emley, Prof. Louis A. Olney.

The Arrangement

Abstracts and Bibliography are arranged alphabetically by major subject under the following classifications:

I. Fibres (Synthetic and Natural) and Fibre Analysis.

II. Yarns and Fabrics.

III. Chemical and Other Processing (Not Otherwise Classified).

IV. Research Methods and Apparatus.

V. Economic Research and Miscellany.

Subjects are followed by name of author, and the abbreviated or complete title of the publication is followed by the year, volume, issue number or date, and the page number or numbers.

A key to abbreviations of publications abstracted was published in Vol. III, No. 1, Nov., 1932, pp. 58–9, and should be preserved for reference as it will not be published again in this volume. Abbreviations of additional publications abstracted will be published in issues of their initial use.

Abstracts

I. Fibres (Synthetic and Natural) and Fibre Analysis

Cellulose: Action of Sodium Carbonate on. E. Paterno. *Atti. accad. Lincei,* 1932, 15, 11–16; *Chem. Abs.,* 1932, V. 26, P. 4946.

The solubilities of various kinds of celluloses in Na_2CO_3 (exhausted cellulose, silk, linters, manufactured cellulose) increased in that order. Apparently the material dissolved by Na_2CO_3 solu. is γ-cellulose, whereas rayon, which is practically insoluble, contains B-cellulose almost exclusively. Manufactured cellulose is high in γ-cellulose which is soluble, and, therefore, should be excluded in the manufacture of rayon. (W)

Cellulose: Hygroscopic Moisture of. V. Drying Celluloses. VI. Hygroscopic Moisture of Raw Cotton and Tissue Paper. S. Oguri. *J. Soc. Chem. Ind. Japan,* Suppl., 1932, V. 35, P. 232–4, 279–82.

Drying various types of cellulose by (1) heating at 105°, (2) in vacuo over P_2O_5 and (3) in vacuo, showed (2) to be most effective and (1) next, but the effectiveness varied with the samples. In general, cellulose with a low hygroscopicity expels moisture by the vacuum method as well as by the heating method. The hygroscopicity of raw cotton and tissue paper prepared from cotton are approximately equal, but greater than that of standard cellulose. (Copied complete from *Chem. Abs.,* 1932, V. 26, P. 4946.) (W)

VII. Regenerated cellulose adsorbs water vapor more readily than natural or mercerized cellulose. Although the origin of cellulose may be different, regenerated cellulose prepared by the same process adsorbs an equal amount of water vapor under similar conditions. The hygroscopic properties of regenerated celluloses are not widely different. (Copied from *Chem. Abs.,* 1932, V. 26, P. 6120.) (W)

Cellulose: Moisture Relations. E. Filby and O. Maass. *Can. J. Rsch.,* 1932, V. 7, P. 162–77.

The absolute specific volume of cellulose has been determined by means of helium gas. A new experimental procedure has been developed, which, it is claimed, is more accurate than any previously used where a small quantity of porous material is involved. The method is extended to include the measurement of the volume of a system resulting from the adsorption of a vapour on a porous material, and applied in this instance to the system cellulose-water vapour. The specific volume of cellulose in helium was found to be 0.640 ± 0.001 c.c. The volume of the system cellulose-water vapour was found to be much smaller than that given by the components cellulose and condensed water, as long as the amount of adsorbed water was below 4 per cent. With more than 8 per cent. of adsorbed water the density of subsequently sorbed water was found to be the same as that of the normal liquid. The hypothesis is put forward that the first water adsorbed on cellulose enters into a definite chemical combination, considerable contraction taking place, and that subsequently adsorbed water first causes an increase in

cellulose surface, with further consequent contraction in the volume of the two components, and then a filling-up of the so-called capillary spaces in which the water maintains its liquid properties. The relation of this hypothesis to the hysteresis effect is indicated, the trend which further work should take is pointed out, and the interest of this problem from a practical point of view is discussed. (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

CELLULOSE AND DERIVATIVES: LYOPHILIC PROPERTIES OF. I–II. HYGROSCOPIC PROPERTIES OF CELLULOSIC SUBSTANCES. K. Kanamaru and K. Shimura. *J. Soc. Chem. Ind. Japan*, Suppl. Binding, 1932, V. 35, P. 329–43; *Chem. Abs.*, 1932, V. 26, P. 6121.

The hygroscopicity of cellulosic substances (1) decreases after "dry heating" as the temperature and duration of heating increase, provided the treatment does not decompose the material; (2) increases after "steaming" or "damp heating" as the temp. of the treatment increases. After prolonged "damp heating" the sample reacts as if "dry heated." The hygroscopicity of viscose fibre decreases after "dry heating" under tension as long as the load applied does not exceed a certain limit, above which the absorption capacity increases. This effect of tension is more evident with "damp heating." (W)

CELLULOSE IN ALKALI: SWELLING OF. III. G. Saito and M. Takahasi. *J. Soc. Chem. Ind. Japan*, Suppl. Binding, 1932, V. 35, P. 326–9; cf. *Chem. Abs.*, 1932, V. 26, P. 2587.

Tables and curves show the cross-sectional swelling and relative changes in length of ramie fibre and cuprammonium rayon in alkali of various concentrations. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 6121.) (W)

COTTON: CHEMICAL PROPERTIES AND COMPOSITION OF. S. Köhler. *Tek. Tid. Uppl. C. Kemi.*, 1931, V. 61, P. 57–64, 68–72; cf. *Chem. Abs.*, 1931, V. 25, P. 5025, 1932, V. 26, P. 5762.

The classification of raw cotton, the chemical analysis and the influences which the content of moisture, water-soluble constituents, wax, fat, ash, nitrogen and phosphorus exert on the physical properties of cotton are discussed. A convenient method to determine the copper number is proposed. Recent investigations on the relation of the speed of bleaching of cotton to the pH of the sodium hypochlorite solution used, and of the consumption of acid of various pH to the copper number, methylene blue number and viscosity, are discussed. The copper number cannot serve as a general quantitative measure for the change in mechanical strength of oxidized cotton cellulose. The more general connections existing between the changes in strength, copper number, solubility in NaOH, and viscosity of hydrocellulose are discussed. (W)

COTTON: GENETICS OF. PART VI. THE INHERITANCE OF CHLOROPHYLL DEFICIENCY IN NEW WORLD COTTONS. S. C. Harland. *J. Genetics*, 1932, V. 25, P. 271–80.

Stroman and Mahoney first drew attention to the occurrence of chlorophyll deficiency in the F_2 between Upland and Sea Island or Egyptian. Segregation gave 15:1 ratio. Evidence of a third factor was obtained

and, in Texas, a form known as virescent yellow has been studied and found to be a simple recessive to normal. In the material studied by the author there was considerable variability in the amount of chlorophyll present in the cotyledons, and a number of deficients were carried to the mature stage by grafting on to normal stocks. Two generations of selection for viability gave rise to a pure chlorophyll-deficient race in which most of the seedlings were capable of arriving at maturity without grafting or special treatment. It has been termed Type 5. The type of chlorophyll-deficiency here studied differs from those previously described in that it occurs only in interspecific crosses and is profoundly affected by modifiers which enable the selection of a viable race. The variability of the expression of the character, enabling it to be classed into nine grades, is traced to modifiers and the results are compared with those for Brassica obtained by Kristofferson and for Drosera referred to by Fisher. (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

COTTON: INHERITANCE OF RESISTANCE TO WILT DISEASE IN. Dr. Tewfik Fahmy. *Bull. No. 95, Ministry of Agriculture, Egypt.*

An investigation of the resistance of Egyptian cotton to the wilt disease and its inheritance. The author classifies plants as susceptible, resistant, or immune according to whether they die as seedlings in infected soil, recover after developing mottled leaves, or show no symptoms. Some Egyptian varieties are completely susceptible, while others show a percentage of resistance and immunity. In crosses, immunity is dominant to susceptibility. The F_2 in one cross (Giza 7 $\times$ Sakha 3) gave 75 per cent. immune, 15 per cent. resistant, and 10 per cent. susceptible. The immunes may segregate or breed true. The resistant plants in F_3 may give all three types or only immune and resistant. In a cross between susceptible and immune, there is an increase in the resistance of susceptible plants, as measured by the incubation period before the symptoms of the disease appear. Also, mother plants with a long incubation period have a higher percentage of immune progeny than those with a shorter incubation period, which are therefore less resistant. The correlation between susceptibility and length of fibre has also been studied. (Copied complete from *Nature*, Sept. 3, 1932.) (S)

COTTON FIBRES: CHARACTERIZATION OF DIFFERENT, BY THE SOLUTION CURVE IN CUPRAMMONIUM SOLUTION. Y. Shinoda. *J. Soc. Chem. Ind., Japan* (Suppl.), 1932, V. 35, P. 295–8.

Each different type of cotton examined by the method of Sakurada (cf. *Chem. Abs.*, 1932, V. 26, P. 2588) showed a characteristic solubility curve. Similar curves are shown for solubility in cuprammonium-sodium hydroxide solutions in which the sod. hydroxide is varied instead of the copper. Maximum solubility is obtained at a concentration of about 11 milligram-mole of NaOH per 100 c.c. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 6148.) (W)

COTTON FIBRES AT VARIOUS STAGES OF MATURITY: CHEMICAL COMPOSITION OF. V. T. Ivanova and A. M. Kurennova. *Trans. Middle Asiatic Sci. Inst. Cotton Culture, Ind. Irrigation, Byull.*, 1931, No. 50, P. 57–71; *Chem. Abs.*, 1932, V. 26, P. 5988.

Cellulose accumulates rapidly up to 40 days of the age of the fibre. At 45 days, 83% of the fibre is cellulose, which is almost equal to the amount of cellulose in the mature cotton. It is concluded that cotton at 50 days is just as good for industrial purposes as mature cotton. (W)

II. Yarns and Fabrics

Rayon: Breaking Strength and Extensibility of. Y. Kami. *Bull. Sericul. and Silk Ind., Japan*, 1931, V. 4, No. 2, P. 9–10.

The breaking strength of rayon yarn is less than the sum of the strengths of the constituent filaments, and, like the extensibility, which is greater than that of a single filament, decreases as the amount of twist increases. With increasing humidity the strength rises to a maximum and then falls again, whereas the extensibility increases continuously. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 4721.) (W)

Stains in Textiles: Occurrence of. T. E. Thompson. *Tex. Recdr.*, 1932, V. 50, No. 590, P. 60–1.

A number of stains which may occur during the manufacturing process are classified according to color. Their possible causes are suggested together with methods of prevention and removal. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 5211.) (W)

Wash Silks: Influence of Laundering and Exposure to Light Upon Some, Used for Outer Garments. M. E. Griffith. *Ohio Agr. Expt. Sta. Bull.*, 1932, No. 506, P. 3–30; cf. *Chem. Abs.*, 1931, V. 25, P. 1678; 1933, V. 27, P. 421.

Chemical and physical characters of 15 washable silk fabrics are given. In general, there was a high degree of correlation between retail price and wearing quality. The weighted silks were stronger when wet than when dry, but were not as strong as the pure-dye silks, which had a greater dry than wet strength. The pure-dye silks showed less decrease in tensile strength upon exposure to light than the weighted silks. Weighted silks showed increased strength after laundering. There was great similarity in the fading of the pure-dye and the weighted silks. For all, there was very slight fading after 12 hours' exposure to light and after 5 launderings. Laundering caused in every case a loss of color. (W)

III. Chemical and Other Processing (Not Otherwise Classified)

Action of Light on Cotton Dyed with Vat Dyestuff. S. D. Vashist. *Indian Textile J.*, 1932, V. 42, P. 376–7.

Vat dyestuffs frequently exert a catalytic action sensitizing cotton to tendering by sunlight. The intensity of the action varies with the dyestuff. Tables showing the catalytic tendering value of different dyes are given. Five conditions are simultaneously required to act on cloth and produce deterioration: An appropriate dye catalyst, oxygen, alkalinity, moisture, and light of short wave length. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 192.) (W)

Color Absorptive Power of Bemberg Silk. II. The Absorptive Power for Basic Dyes. U. Miyaoka and T. Tsubota. *"Shikisen" (Dyeing)*. 1932, V. 3, P. 339–43; *Abstracts Japan. Chem. Lit.*, 1932, V. 6, P. 513.

The absorptive power for chrysoidine, rhodamine G and crystal violet was determined at various temperatures with varying concentrations of neutral salt. The absorptive power for basic dyes of this silk is so weak that the use of basic dyes is uneconomical unless very clear nuance is wanted. To obtain light colors a temperature of 30° is sufficient. Deep color is obtained by boiling with 10% of neutral salt. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 421.) (W)

IV. Research Methods and Apparatus

A Centrifuge-Microscope. *Sci. Mo.*, July, 1932, P. 95.

This device permits the observation of the changes taking place within cells as they are subjected to a centrifugal force. The cell is placed at one end of the hollow bar and is whirled about on the turntable. By means of a series of lenses and mirrors within the bar the image of the cell is carried to the center of the bar so that it is within the range of the suspended eye-piece. The small mercury light, seen above the end of the bar, flashes on the revolving cell as it passes beneath, creating a series of images which afford the observer a continuous and steady picture of the cell. The principle is similar to that of a motion picture projector. (S)

Determination of the Weakening of Textile Materials Through Washing. H. Pomeranz. *Seifensieder-Ztg.*, 1932, V. 59, P. 605–7.

Tensile strength and similar determinations of the fibre before and after washing are not criteria of its wearing quality. An abrasion test has been developed by the Vienna "Laboratorium Serivalor" which gives reliable results as to the probable service time of any given fabric. The test is based upon the fabric's resistance to abrasion, and takes into consideration time, pressure and speed of the abrasion apparatus, by which a known area of the material is worn through. No details are published. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 6147.) (W)

Dyes: Visual Spectrophotometry of. W. C. Holmes, J. T. Scanlan and A. R. Peterson. *U. S. Dept. Agric. Tech Bull.*, 1932, No. 310, P. 1–41; *Chem. Abs.*, 1932, V. 26, P. 5761.

A detailed description is given of the equipment and technic for visual spectrophotometry. The influence which various conditions (solvent, dye concentration, temperature, colloidal state, hydrogen ion concentration) exert on the absorption of dyes is discussed. Many practical applications of such spectra for dye identification evaluation and indicator practice are given. Tables are included showing the absorption ratios of various dyes and the solubilities of representative dyes in water and in 95 per cent. alcohol at 26°. A bibliography of 58 references is appended. (W)

V. Economic Research and Miscellany

An Automobile Man Looks at the Textile Industry. Paul R. Collier. *Tex. Wld.*, Dec., 1932, P. 58–9.

A background of practical experience in wool manufacturing adds weight to the author's comparisons between the mechanical and merchandizing status of the two industries, all of the textile examples being drawn from the woolen industry and designed to show the relative backwardness of the latter. His claim that "woolen manufacturing conducts the least research" represents unwarranted differentiation between that and other branches of the textile industry. He emphasizes the fact that: "Research must be constant and unrelenting if any industry is to survive. The results of that research must be passed on so that the entire industry will benefit." (C)

Bibliography

I. Fibres (Synthetic and Natural) and Fibre Analysis

Cotton, Genetics of: Inheritance of Vegetative and Physiological Characters in Cotton and a Discussion of Further Questions Relating to the. *Der Zuchter,* 1932, V. 4, P. 39–49.

A brief, but comprehensive review of the published work on the classification, chromosome numbers and genetics of cotton. (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

Cotton Breeding Today Works with Main Types Known in Remote Past. T. H. Kearney. *Yearbook, U. S. Dept. Agric.,* 1930, P. 182–90.

A very brief historical account of selection in Sea Island and Egyptian, Upland and Asiatic cottons, of the methods of breeding. The necessity for isolation of the multiplication plots and for continuous rouging is emphasized. (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

Cotton Gin: Research on. C. Vinson. *Cotton and Cotton Oil News,* 1932, V. 33, No. 38, P. 8–9.

A short discussion of the development of the gin, the use of mechanical driers, and investigations of speeds and efficiencies; the effects of ginning on staple, the influence of moisture and various other problems of ginning in progress at various American laboratories and experiment stations. (Copied complete from *J. T. I.* abstract Section, Dec., 1932.) (S)

Cotton Plant: An Unusual. A. F. Kidder, *Science,* Sept. 30, 1932, P. 295.

A brief description of a plant producing cotton 1⅛ inch to 1¾ inch staple. (S)

Cotton Plant: Pathological Anatomy. K. Dharmarajulu. *Indian J. Agric. Sci.,* 1932, Vol. 2, P. 293–313.

An account is given of a study of the pathological anatomy of the cotton plant in connection with wilt disease. (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

Cotton Plants: Is Ammonium Hydroxide Toxic to. L. G. Willis and W. H. Rankin. *Science,* Sept. 2, 1932, P. 214.

A reply to criticism of an article on this subject by the authors appearing in the June 17 issue of *Science.* It was stated that free ammonia was the cause of the injury observed. (S)

Pigment of Green Japanese Silkworm Cocoon. (1) C. Jucci and C. Manunta and (2) C. Jucci. *Boll. soc. ital. biol. sper.,* 1932, V. 7, (1) P. 162; (2) 163–5. (Through *Chem. Abs.,* 1932, V. 26, P. 4885.)

(1) The pigment is soluble in water, but only sparingly soluble in 95 per cent. alcohol. With alkali it gives a yellow salt, insoluble in 95 per

cent. alcohol. (2) The pigment belongs to the flavone group. It is suggested that it is absorbed from the mulberry leaves by the larva and passes from the blood to the silk glands. Concentrated sulphuric acid changes its colour from a yellowish to a brilliant green, whilst with ferric chloride or ferrous sulphate it becomes brownish. (Copied complete from *J. T. I.* Abstract Section Dec., 1932.) (S)

III. Chemical and Other Processing (Not Otherwise Classified)

Aspergillus Niger: Acid Resistance. E. Kadelbach. *Botan. Centr.*, 1932, V. 21, P. 80. (From *Jahrb. wiss. Botan.*, 1931, V. 75, P. 399–438.) (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

Bleaching of Textiles by Hypochlorites: Deteriorations Which Can Take Place During the. J. Ernst. *Monatschr. Textil-Ind.*, 1931, V. 46, P. 395; *Chim. et Ind.*, 1931, V. 28, P. 156–7.

A general discussion. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 5212.) (W)

Bleaching with Peroxides. P. W. Hargreaves. *Dyer*, 1932, V. 68, P. 397–9, 453–4.

The following topics are discussed: Bleaching plant for Na_2O_2 and H_2O_2; bleaching cotton, wool and linen with peroxide; sources of H_2O_2; testing the liquors; and the use of sodium perborate as a bleaching agent. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 194.) (W)

Colloid Aspects of Textile Materials. J. B. Speakman. *Nature*, Oct. 8, 1932, P. 532.

A brief article giving more or less the summation of the discussion which took place at the recent meeting of the Faraday Society at the University of Manchester, England. In addition to a brief consideration of x-ray structure, emphasis is placed on the determinations of the mean molecular weight of cotton cellulose which may possibly be in the neighborhood of 30,000. (S)

Colloids: Significance in Silk Mills. Benjamin Levitt. *Silk*, 1932, V. 25, No. 8, P. 36–7; *Chem. Abs.*, 1932, V. 26, P. 5762. (W)

Dyeing Wool with Alizarin. S. Chatti. *Indian Text. J.*, 1932, V. 42, P. 419–22.

Properties of wool mordanting and dyeing are discussed. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 192.) (W)

Fastness to Light: Influence of Depth of Dyeing on Degree of. I. Khailon. *Anilinokrasochnaya Prom.* 1932, V. 2, No. 2, P. 27–36; *Chem. Abs.*, 1932, V. 26, P. 4721. (W)

Hypochlorite Bleaching: Chemistry of. M. M. Chilikin. *Izvestiya Tekstil. Prom. Torgov.* 1931, V. 10, No. 9, P. 47–52; *Chim. et Ind.*, 1931, V. 28, P. 155–6.

A review of the reactions involved in the hypochlorite bleaching of textiles. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 5212.) (W)

LUSTRE: HOW MAY INCREASED, BE PRODUCED BY MERCERIZATION? Otto Mecheels. *Mell. Textilber.*, Dec., 1932, P. 645.

An article including numerous charts and tables descriptive of an ingenious method for treating textiles experimentally with mercerizing solutions, and concluding with a diagram outline of what is stated to be substantially optimum conditions for mercerization of both yarn and fabric. (S)

MILDEW IN THE TEXTILE INDUSTRY. Walter Garner. *The Ind. Chem.*, Dec., 1932, P. 445.

The author divides his work into the following sections: the effect of growth of mildew upon textile materials; a description of the organisms responsible; the factors governing their growth; and practical applications of work upon the limitation of their growth. A bibliography of nineteen items, largely from *J. T. I.*, is appended. (S)

OILS FOR WOOL, RAYON, SILK AND COTTON. W. F. Vichers. *Trans. Inst. Chem. Engrs.* (London), 1931, V. 9, P. 86–9.

An explanation of the reasons for which the use of oil is necessary in the processing of textiles, and of the characteristics required of oils used for this purpose. (Copied complete from *Chem. Abs.*, 1932, V. 26 P. 6146.) (W)

OXIDIZABLE OILS IN THE TEXTILE INDUSTRY. Kehren. *Z. ges. Textil-Ind.*, 1932, V. 35, P. 292–4, 304–5.

A review. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 6146.) (W)

PLASTICIZERS: NEW FACTS ON. *Plastics*, July, 1932, P. 280.

In a series of three patents assigned to Eastman Kodak Company, Henry B. Smith describes a novel composition combining large proportions of plasticizers heretofore used in modest quantities, resulting in improved qualities in film, artificial leather and other products. (S)

SCREEN PRINTING OF TEXTILES. T. C. Wenham. *Dyer*, 1932, V. 68, P. 467–9.

Illustrated descriptions are given of the construction of the table, the preparation of the screen, and the construction and use of the squeegee. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 192.) (W)

VAT DYESTUFFS: SELECTION OF, FOR THE "GUARANTEED FADELESS" TRADE. V. D. Rollington. *Dyer*, 1932, V. 68, P. 451–2, 457.

The dyeing properties of many specific vat dyestuffs, when used alone or in combination, are discussed. Twenty-two dyestuffs that accelerate tendering of viscose rayon on exposure are listed. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 191.) (W)

VEGETABLE LAKES AND THEIR FUTURE. Geo. Zerr. *Farbe u. Lack.*, 1932, P. 521–2, 537–8.

The use of color lakes from vegetable sources is still considerable. A selected list of such lakes is briefly described. (Copied complete from *Chem. Abs.*, 1933, V. 27, P. 192.) (W)

VISCOSE: VISCOSITY OF. S. Iwasaki and E. Sugino. *J. Soc. Chem. Ind., Japan (Suppl.)*, 1932, V. 35, P. 358B–60B.

(Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

VISCOSE: VISCOSITY OF. T. Nakashima. *J. Soc. Chem. Ind., Japan (Suppl.)*, 1932, V. 35, P. 355B–8B.

(Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

IV. RESEARCH METHODS AND APPARATUS

ATMOSPHERIC HUMIDITY: APPARATUS FOR MAINTAINING NORMAL. S. A. Chentzov. *Izvestiya Tekstil. Prom. Torgov.*, 1931, V. 10, No. 8, P. 48–50; *Chim. et Ind.*, 1931, V. 28, P. 155.

Three simple devices are described. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 5211.) (W)

COLOR: A NEW METHOD FOR THE DETERMINATION OF THE QUALITY OF. J. Pinte and R. Toussaint. *Mell. Textilber.*, Dec., 1932, P. 650.

A description of a series of determinations carried out by means of the Toussaint photo-electric colorimeter. Color intensities through the spectrum are measured in terms of the current developed in the photo-cell as noted by means of a galvanometer. (S)

CONTROL INSTRUMENTS: CARE AND MAINTENANCE OF. Roosevelt Griffiths. *The Ind. Chem.*, Nov., 1932, P. 370.

A brief article of interest to all laboratory workers who must maintain recorders of various types in efficient operation. (S)

CONTROLLED HUMIDITY IN WOOLEN AND WORSTED MILLS. S. G. Barker and M. C. Marsh. *Engineering*, 1932, V. 134, P. 493–4; *Chem. Abs.*, 1933, V. 27, P. 192. (W)

DETERMINATION OF LEAD IN ORGANIC MATERIAL WITH SPECIAL REFERENCE TO DYESTUFFS: NEW METHOD FOR THE. Noel L. Allport and G. H. Shrimshire. *Analyst*, 1932, V. 57, P. 440–9; *Chem. Abs.*, 1932, V. 26, P. 4555.

A colorimetric method, based on the formation of a red compound of lead with diphenylthiocarbazone, which is insoluble in water but soluble in chloroform. The compound is then converted to the sulfide. (W)

MODERN TESTING METHODS IN TEXTILE INDUSTRY. Carl Zeiss. *Ind. Textile J.*, 1932, V. 42, P. 346–7.

Microscopical methods are described. (Copied complete from *Chem. Abs.*, 1932, V. 26, P. 5761.) (W)

PHOTOGRAPHY: DEVELOPMENTS IN INFRA-RED. *The Ind. Chem.*, Dec., 1932, P. 433.

An interesting account of the use of the new Infra-red plates, which includes one photograph of eight pieces of cloth all of which appear black to the eye, but are quite different in the picture. (S)

PULFRICH PHOTOMETER: APPLICATION TO HETEROCHROMATIC MEASUREMENTS. E. Mayer. *Physik. Z.*, 1932, V. 33, P. 665–70.

The Pulfrich photometer is suitable for heterochromatic measurements and gives results of the same order of size as those of other methods. A method of comparing complementary colours is described which depends on neutralisation of the two colours to grey, and also on a direct comparison of the brightness of the two. It is shown that this method is simpler and more reliable than the step method. (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

SCIENTIFIC APPARATUS AND LABORATORY METHODS. *Science*, Dec. 30, 1932, P. 626.

A brief description with diagrams of the apparatus. (S)

YARN COUNTS CALCULATOR. H. L. Scott Co. *Tex. Wkly.*, 1932, V. 10, P. 158.

A slide rule is described of the double dial type. The outside circle is graduated in grains per lea and the inner dial has the corresponding counts for cotton, worsted, wool (runs and cuts), jute, asbestos, silk and rayon and also the 'Typp' numbers (thousands of yards per lb.). (Copied complete from *J. T. I.* Abstract Section, Dec., 1932.) (S)

V. ECONOMIC RESEARCH AND MISCELLANY

COMPETITION TAKES ITS TOLL. E. G. Field. *Cotton*, Dec., 1932, P. 32.

The article states: "too much attention has been given to fighting for the immediate advantage of volume that will permit of higher capacities as a means to cut costs. In the meantime, sufficient attention has not been given to the lowering of the real costs as a way to improve the competitive position, and thus to permit of continuance in operation, so as to be able to take advantage of the profit-making opportunity that will be offered with the turn back towards normal." (S)

"Scientific research is accelerated experience."—Anon.

Publications Abstracted

A Key to Abbreviations of Publications Used in Abstracts and Bibliography

(Continued from January Issue)

Abstracts Japan. Chem. Lit. .....*Abstracts of Japanese Chemical Literatures*
Atti. accad. Lincei .....*Atti della reale accademia nazionale dei Lincei*
Boll. soc. ital. biol. sper. .....*Bollettino societa italiana di biologia sperimentale*
Botan. Centr. .....*Botanisches Centralblatt*
Bot. Gaz. .....*Botanical Gazette*
Bull. Inst. Phys. Chem. Rsch. (Tokyo) .....*Bulletin of the Institute of Physical and Chemical Research (Tokyo)*
Farbe u. Lack. .....*Farbe und Lack*
Indian J. Agr. Sci. .....*Indian Journal of Agricultural Science*
Indian Textile J. .....*Indian Textile Journal*
Jahrb. wiss. Botan. .....*Jahrbucher für wissenschaftliche Botanik*
J. Genetics .....*Journal of Genetics*
Monatschr. Textil-Ind. .....*Monatschrift für Textil-Industrie*
Physik. Z. .....*Physikalische Zeitschrift vereinigt mit dem Jahrbuch der Radioaktivitat und Elektronik*
Sci. Mo. .....*Scientific Monthly*
Seifensieder-Ztg. .....*Seifensieder-Zeitung*
Tek. Tid. Uppl. C. Kemi. .....*Teknisk Tidskrift Upplaga C. Kemi och Bergsvetenskap*
Tex. Recdr. .....*Textile Recorder*
The Ind. Chem. .....*The Industrial Chemist and Chemical Manufacturer*
Trans. Inst. Chem. Engrs. (London) .....*Transactions of the Institution of Chemical Engineers (London)*
Z. ges. Textil-Ind. .....*Zeitschrift für die gesamte Textil-Industrie*